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DEPARTMENT OF FISH AND WILDLIFE
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16 June 2008

Kelly McLain
Water Quality Program
Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Dear Kelly,

Enclosed is a hard copy of the report for Zooplankton Monitoring during the years 2002-2003 through 2005-2006, per Section S2 of the WDFW Fish Management Permit No. WA0041009.

I had emailed a *.pdf file of this report to you last Friday, June 13th.

If you have any questions, please feel free to give me a call at 360-902-2711 or email anderjda@dfw.wa.gov.

Sincerely,

Jon. Anderson, Fish Program
Resident Native Species Fisheries Coordinator

encl

ZOOPLANKTON MONITORING REPORT

WDFW FISH MANAGEMENT PERMIT
NPDES PERMIT No. WA0041009

For the years 2002-2003 through 2005-2006

June 2008

Prepared for:
Department of Ecology
Water Quality Program

By: Jon. D. Anderson
Washington Department of Fish and Wildlife
Native Freshwater Species Coordinator
Olympia, Washington

Introduction

With their gill-like tracheae, aquatic invertebrates are theoretically as susceptible to the toxic effects of rotenone as fish or amphibian larvae (Bradbury 1986). After laboratory based tests, Chandler and Marking (1982) concluded that, apart from an ostracod (*Cypridopsis sp.*), aquatic invertebrates are generally more tolerant of rotenone than most fishes and amphibian larval stages. In their study the most resistant organisms exposed were a snail (*Helisoma sp.*) and the Asiatic clam (*Corbicula manilensis*) for which the LC_{50} 96h concentrations were 50 times greater than those Marking and Bills (1976) reported for the Black bullhead (*Ictalurus melas*), one of their most resistant fishes. Sanders and Cope (1968) also conducted lab tests examining the effect of rotenone to the nymph or naiad stage of a stonefly (*Pteronarcys californica*). They found that the LC_{50} 24h was 2,900 µg/L and the LC_{50} 96h was 380 µg/L. These values are greater by an order of magnitude to those found by Marking and Bills (1976) for the black bullhead (*Ictalurus melas*), indicating that some aquatic invertebrates are much less sensitive to rotenone than fish. Larger, later instar naiads were less susceptible to given concentrations of toxin than were smaller, earlier instars of the same species (Sanders and Cope, 1968).

The immediate effect of rotenone on zooplankton communities can be catastrophic (Bradbury 1986), and we expect that at least 50% of the cladocerans and copepods present would die from exposure to rotenone concentrations (0.5 to 4.0 ppm) commonly used in fisheries management projects. There is general agreement that the planktonic crustaceans, especially cladocerans, are the group most affected, and rotifers are deemed more resistant to rotenone. Bradbury (1986) estimated that zooplankton would be reduced to non-measurable levels for a period from two to twelve weeks. Once plankters reappear, the community begins to rebuild, eventually returning to pre-treatment levels and diversity.

The Washington Department of Fish and Wildlife obtained National Pollutant Discharge Elimination System (NPDES)/Waste Discharge Individual Permit No. WA0041009 in July, 2002 to apply rotenone, an aquatic pesticide used to manage fish populations in lakes and streams in the State of Washington. The safe and effective treatment of populations of undesirable fish species improves aquatic and riparian fish and wildlife habitats, establishes conditions favorable for the growth of desirable game fish species, and promotes the social and economic benefits of a healthy recreational fishery in the lakes that have been treated.

Special condition S2 of the NPDES requires sampling of zooplankton in treated lakes according to the protocols set forth in "Water Quality Assessments of Selected Lakes within Washington State 1998", Department of Ecology, December 2000, Publication No. 00-03-039, (NPDES Appendix B). Sampling frequency was set at pre-treatment, six months post-treatment, and one year post-treatment. Samples were to be analyzed for relative abundance of cladocerans and copepods, and their mean length, and tabulated as the ratio of total cladocerans: total copepods.

Sampling Results

Table 1 presents the lakes treated during the years 2002-03 through 2005-06. Sixty-five samples were taken for analysis from 23 lake rehabilitation projects.

Table 1. Locations and dates for samples of zooplankton sampled under NPDES Permit No. WA0041009 from 2002-03 through 2005-06.

LAKES TREATED 2002-03	TREATMENT DATE	PRE-TREATMENT	SIX MONTHS	ONE YEAR
ALTA LAKE	10/15/2002	10/01/2002	**NOT SAMPLED**	11/14/2003
BADGER LAKE	10/22/2002	10/21/2002	**missing**	10/01/2003
DIBBLE LAKE	10/16/2002	10/15/2002	**NOT SAMPLED**	**NOT SAMPLED**
ANCIENT LAKE (SOUTH)	10/17/2002	10/17/2002	04/25/2003	11/07/2003
NORTH SILVER LAKE	10/24/2002	10/23/2002	**missing**	**missing**
WILLIAMS LAKE	10/25/2002	10/25/2002	Apr-03	**missing**
MARTHA LAKE	03/25/2003	03/25/2003	10/24/2003	**missing**
DAVIS LAKE	04/07/2003	**NOT SAMPLED**	11/14/2003	04/19/2005
2003-04				
FISHTRAP LAKE	10/06/2003	10/01/2003	06/08/2004	10/27/2004
HOG CANYON LAKE	10/07/2003	10/01/2003	04/26/2004	10/27/2004
WILLIAMS LAKE	10/08/2003	10/01/2003	06/08/2004	10/27/2004
DUSTY LAKE	11/04/2003	11/04/2003	**missing**	10/16/2004
BLUE LAKE (Sinlahekin)	11/14/2003	11/14/2003	**missing**	11/24/2004
2004-05				
Pillar Lake	10/12/2004			
Snipe Lake	10/15/2004			
Cattail Lake	10/15/2004			
Gadwall Lake	10/15/2004			
Poacher Lake	10/19/2004			
Lemna Lake	10/15/2004			
Shoveler Lake	10/15/2004			
Sago Lake	10/14/2004			
Hourglass Lake	10/14/2004			
Widgeon Lake	10/14/2004			
UPPER HAMPTON LAKE	10/13/2004	10/13/2004	05/12/2003	04/22/2006
Lower Hampton	10/13/2004			
Hen Lake	10/13/2004			
Dabbler Lake	10/14/2004			
Hampton Slough	10/13/2004			
Marie Lake	10/13/2004			
NORTH POTHOLES	10/01/2004	09/30/2004	06/10/2005	11/15/2005
FISH LAKE	10/09/2004	10/09/2004	04/15/2005	10/15/2005
SILVER NAIL LAKE	10/21/2004	10/20/2004	04/15/2005	NOT ANALYZED
ELLEN LAKE	10/26/2004	10/26/2004	04/28/2005	10/25/2005
ROCKY LAKE	10/26/2004	10/25/2004	04/27/2005	10/25/2005
RAT LAKE	05/10/2005	05/09/2005	11/15/2005	05/17/2006
Mouse Pond	05/10/2005			
2005-06				
SPECTACLE LAKE	10/17/2005	NOT IN REPORT	NOT ANALYZED	NOT ANALYZED
BIG GREEN LAKE	10/12/2005	10/11/2005	04/17/2006	NOT ANALYZED
QUINCY LAKE	10/10/2005	10/10/2005	04/11/2006	09/26/2006
BURKE LAKE	10/10/2005	11/15/2005	04/10/2006	09/26/2006

Due to staff changes in the WDFW District 6 office, four required samples were not obtained from the 2002-03 lake treatments. The six-month samples at Alta and Dibble Lakes, the one-year sample at Dibble Lake, and the pre-treatment sample at Davis Lake were not taken. Zooplankton samples taken during the 2002 and 2003 treatment seasons were provided to Eastern Washington University and stored prior to analysis. When retrieved by WDFW, the following samples were discovered to be missing: the six-month samples from North Silver, Dusty, and Blue (Sinlahekin) lakes, the pre-treatment and six months post-treatment sample from Badger Lake, and the one-year samples from North Silver and Martha lakes, and Williams Lake (Stevens County).

Second and third samples taken following the 2005 treatment of Spectacle Lake, and one-year samples taken at Silver Nail and Big Green lakes in Okanogan County have not yet been submitted for analysis; the results will be reported in a subsequent WDFW report.

Results of Analyses

WDFW contracted with Eastern Washington University to analyze zooplankton samples, and shipped samples to the EWU laboratory where they were stored until analysis. Circumstances required WDFW to re-obtain their samples after EWU had analyzed 17 of them. The samples analyzed by EWU included the Badger Lake sample on 21 October 2003; Fishtrap Lake samples on 1 October 2003, 8 June 2004, and 27 October 2004; Hog Canyon Lake samples taken 1 October 2003, 26 April 2004 and 27 October 2004; a Martha Lake sample taken 25 March 2003, an Ellen Lake sample taken 26 October 2004, a composite of Davis Lake samples taken 19 April 2005, South Ancient Lake samples taken 17 October 2002 and 25 April 2003, Williams Lake (Spokane Co.) samples taken 1 October 2003, 8 June 2004 and 27 October 2004, and Williams Lake (Stevens Co.) samples taken 25 October 2002 and April 2003. The EWU sample analyses reported back to WDFW did not include the required average zooplankton lengths.

Subsequently, biologists working with the WDFW Large Lakes Research Team (LLRT) analyzed the remaining samples included in this report. The ratio of cladocerans to copepods, and mean lengths of each are shown in Table 2.

The attached report (Appendix I) from the WDFW Large Lakes Research Team is appended with the data received from EWU (Appendix II). Note that the report from the LLRT also includes results of analyses of a portion of the zooplankton samples taken in 2006-2007. The final results of samples taken subsequent to those treatments will be reported when results of analyses from the second and third sampling collections are available.

The response of zooplankton to the effects of the rotenone treatments was variable in each of the lakes sampled. In general, the ratio of cladocerans to copepods tended to decline significantly after six months post-treatment, then was found to have returned to near pre-treatment levels at one year post-treatment. The average length of cladocerans showed an inconsistent response at six months post-treatment, and generally were slightly larger at one year post-treatment. Copepod average lengths also showed inconsistent response at six months post-treatment, and tended to increase in size or remain the same at one year post-treatment (Table 3).

2002-2003

Alta Lake (Okanogan Co.), treated on 15 October 2002, was sampled only twice, once at the time of treatment, and at one-year post-treatment. Samples analyzed by the LLRT showed the ratio of cladocerans to copepods changed from 0.009:1 at the time of treatment to 0.901:1 one year later. The size of copepods did not change during that time. The lab was unable to determine average length for cladocerans at pre-treatment, but found an average size of 0.826 mm at one year post-treatment. The pre-treatment sample analyzed by EWU is displayed as a chart in Figure 1.

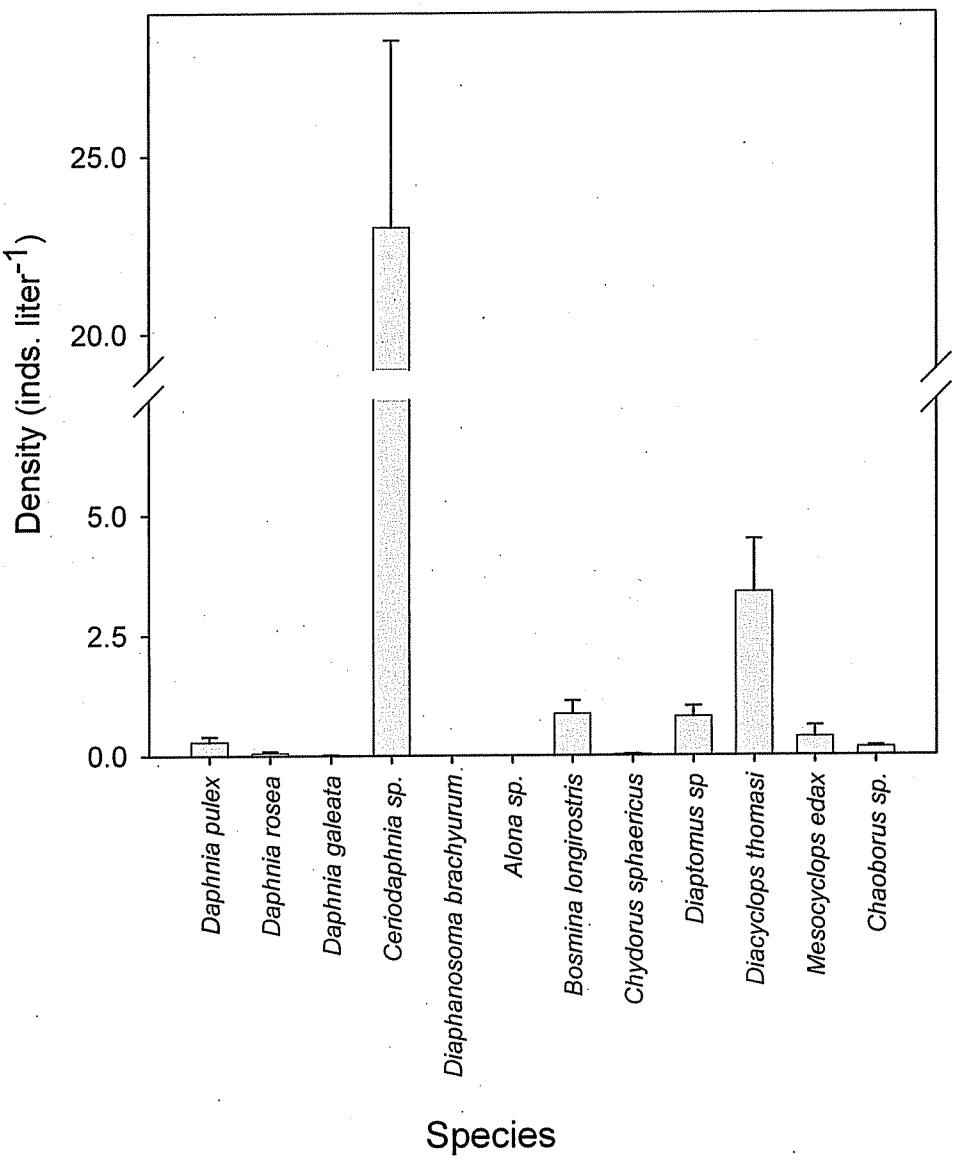

Figure 1. Alta Lake zooplankton densities. Values reperesent mean and standard error of density (inds. liter-1), determined from five replicate vertical zooplankton tows collected just above bottom to surface from each of five separate locations on the lake. All samples were collected Autumn 2002.

Badger Lake (Spokane Co.), treated 22 October 2002, was sampled on 21 October prior to treatment and on 1 October 2003 at one year post-treatment. EWU provided a chart of zooplankton densities for the Autumn 2002 sample (Figure 2), but data to determine the ratio of cladocerans to copepods are not available. The sample taken six-months post-treatment was found to be missing at the time of analysis. The one year post-treatment sample taken 1 October 2003 was analyzed by EWU, and the ratio of cladocerans to copepods was found to be 0.95:1, or nearly even.

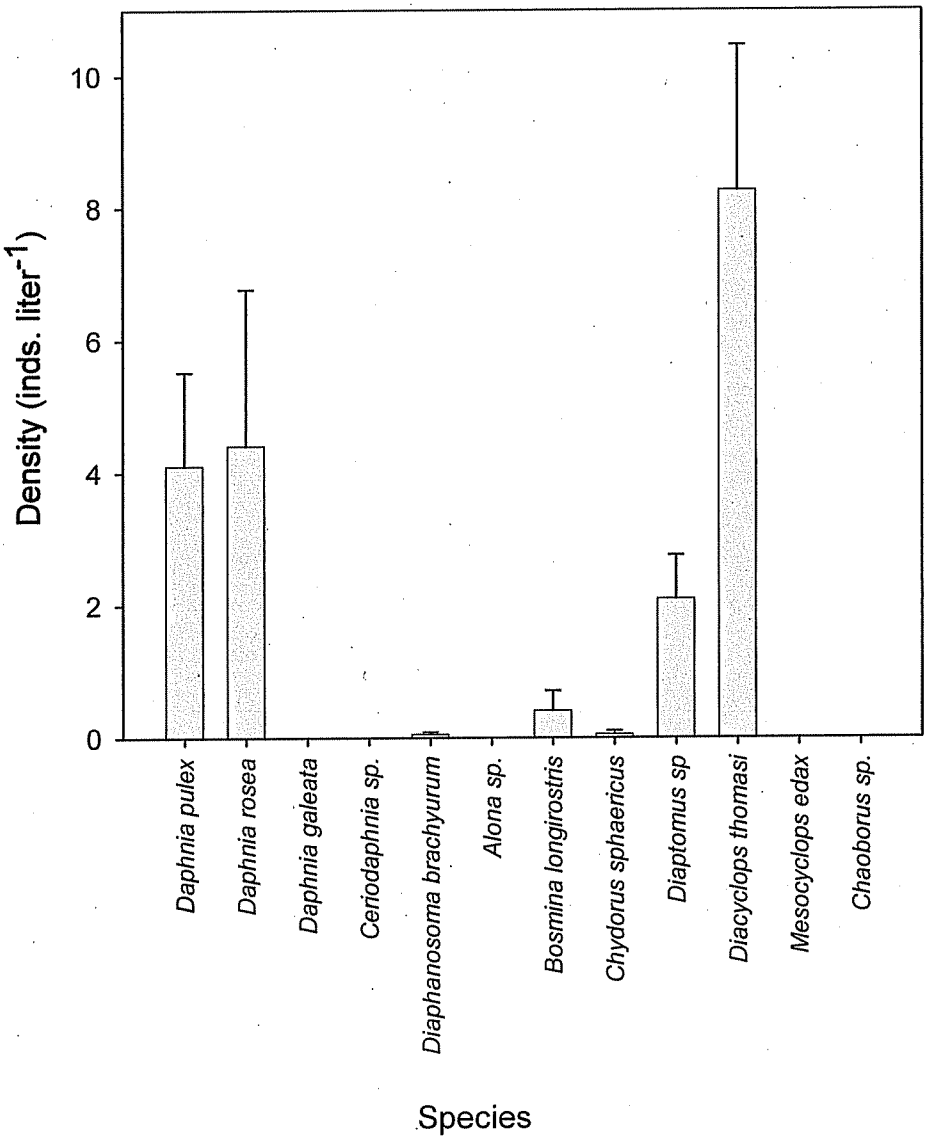

Figure 2. Badger Lake zooplankton densities. Values reperesent mean and standard error of density (inds. liter-1), determined from five replicate vertical zooplankton tows collected just above bottom to surface from each of five separate locations on the lake. Samples were collected Autumn 2002.

Dibble Lake (Okanogan Co.) was sampled only at the time of treatment on 16 October 2002. The EWU lab provided a chart of zooplankton densities, labeled as "Piddle Lake" in Figure 3, but data to determine the ratio of cladocerans to copepods are not available.

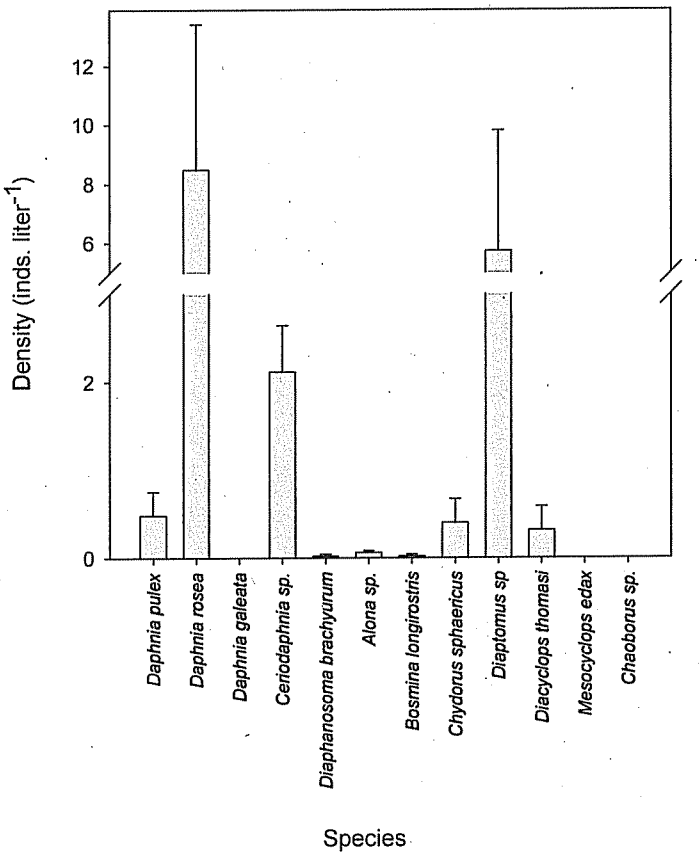

Figure 3. Piddle Lake zooplankton densities. Values reperesent mean and standard error of density (inds. liter^{-1}), determined from two replicate vertical zooplankton tows collected just above bottom to surface from each of two separate locations on the lake. Samples were collected Autumn 2002.

South Ancient Lake (Grant Co.) was sampled at the time of treatment on 17 October 2002, six months post-treatment, and one year post-treatment. At the time of treatment, the ratio of cladocerans to copepods was found to range from 0.602:1 to 1.23:1 in the LLRT samples, and was 0.47:1 in the EWU sample. On 25 April 2003, this ratio declined to 0.039:1 in the six-month sample analyzed by EWU, due to significant increases in densities of copepods. The ratio returned to pre-treatment ratios on 7 November 2003, with densities of 0.56:1 and 0.72:1. The average size of cladocerans increased significantly from the pre-treatment size of 0.352 mm to 0.400 mm, to 1.061 mm to 1.173 mm one year post-treatment. The size of copepods was similar pre-treatment and one year post-treatment, ranging from 0.742 mm to 0.883 mm.

North Silver Lake, (Spokane Co.), was treated 24 October 2002. Samples taken six months and one year post-treatment were found to be missing at the time of analysis. The EWU lab, which provided the chart of cladoceran and copepod densities displayed in Figure 4, analyzed the sample taken at the time of treatment but data to determine the ratio of cladocerans to copepods are not available.

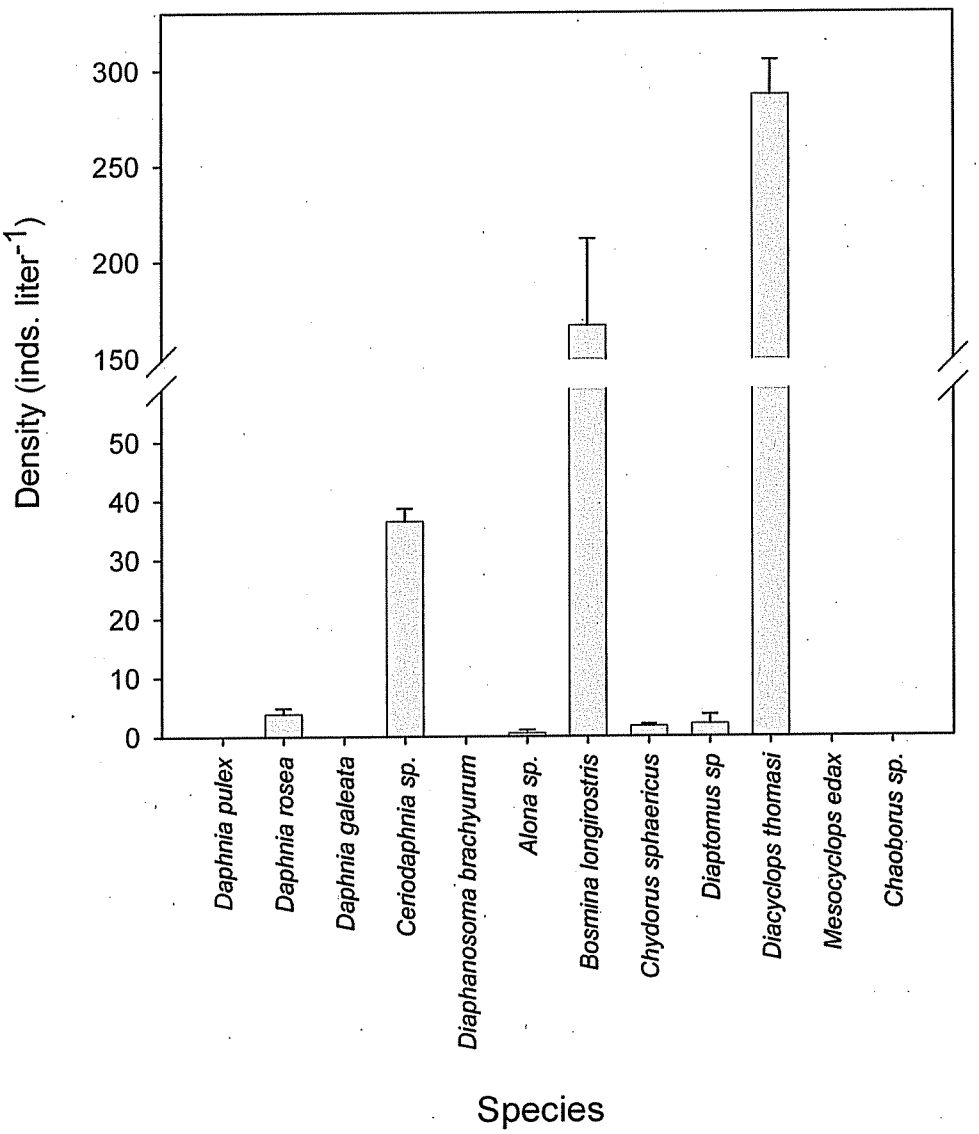

Figure 4. North Silver Lake zooplankton densities. Values reperesent mean and standard error of density (inds. liter^{-1}), determined from five replicate vertical zooplankton tows collected just above bottom to surface from each of five separate locations on the lake. Samples were collected Autumn 2002.

Williams Lake (Stevens Co.) was sampled at the time of treatment on 25 October 2002, and in April 2003 at six months post-treatment. The sample taken one year post-treatment was found to be missing at the time of analysis. The EWU lab, which provided the chart of pre-treatment cladoceran and copepod densities displayed in Figure 5, analyzed the sample taken at the time of treatment to determine the ratio of cladocerans to copepods as 4.22:1. The zooplankton sample taken at six month post-treatment was analyzed by EWU, who reported and the ratio of cladocerans to copepods had declined to 0.30:1

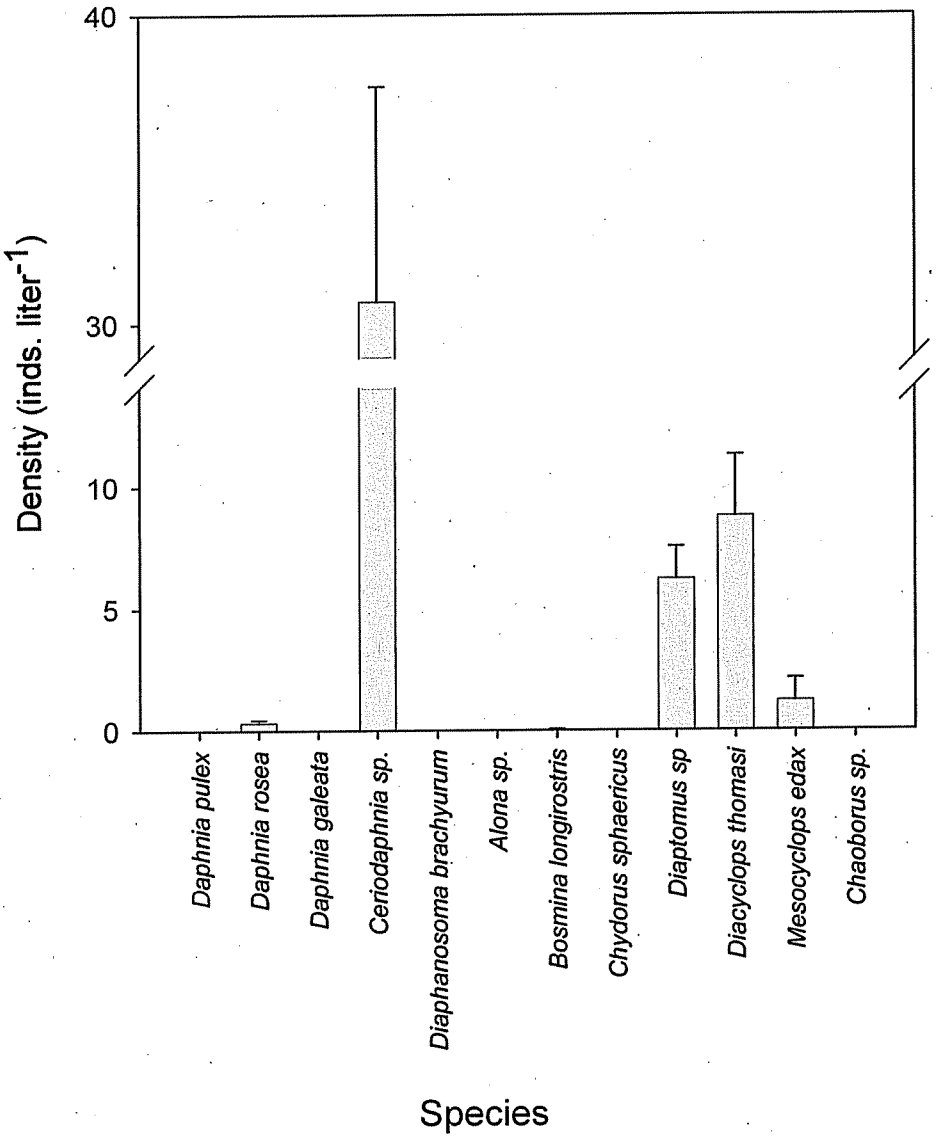

Figure 5. Williams Lake zooplankton densities. Values reperesent mean and standard error of density (inds. liter^{-1}), determined from five replicate vertical zooplankton tows collected just above bottom to surface from each of five separate locations on the lake. Samples were collected Autumn 2002.

Martha Lake (Grant Co.) was sampled at the time of treatment on 25 March 2003, and six months post-treatment on 24 October 2003. The sample taken one year post-treatment was found to be missing at the time of analysis. At the time of treatment, the ratio of cladocerans to copepods ranged from 0.36:1 to 2.95:1, and had increased significantly when the samples were taken in October, ranging from 10.90:1 to 16.30:1. The average lengths of cladocerans ranged from 0.596 mm to 0.722 mm pre-treatment, and were found to have increased significantly to 0.925 mm to 1.124 mm at six months post-treatment. The average lengths of copepods increased slightly from 0.786 mm to 0.829 mm pre-treatment to 0.925 mm to 1.124 mm at six months post-treatment.

Davis Lake (Okanogan Co.) was not sampled at the time of treatment on 7 April 2003, but was sampled at six months post-treatment on 14 November 2003. The WDFW District 6 fish biologist took a sample at two years post-treatment on 19 April 2005, when it was determined that the one-year sample had not been taken. The cladoceran to copepod ratio at six months post-treatment was 12.20:1 as determined by the LLRT. This ratio had increased to 29.73:1 when the EWU lab analyzed the sample taken two years post-treatment. At six months post-treatment, the average length of cladocerans was 1.012 mm and that of copepods was 1.301 mm.

2003-2004

Fishtrap Lake (Lincoln and Spokane Counties) was sampled on 1 October 2003, prior to treatment, on 8 June 2004 at six months post-treatment, and on 27 October 2004 at one year post-treatment. The EWU lab provided data to determine the ratio of cladocerans to copepods. The pretreatment ratio was 2.46:1, and increased to 7.37:1 at six months post-treatment and to 8.45:1 at one year post-treatment.

Hog Canyon Lake (Spokane Co.) was sampled prior to treatment on 1 October 2003, on 26 April 2004 at six months post-treatment, on 8 June 2004 at eight months post-treatment, and on 27 October 2004 at one year post-treatment. The EWU lab provided data to determine the ratio of cladocerans to copepods. The pretreatment ratio was 12.63:1, and declined to 3.09:1 at six months post-treatment, again increased to 4.40:1 at 8 months post-treatment, and declined again to 0.68:1 at one year post-treatment.

Williams Lake (Spokane Co.) was sampled on 1 October 2003 prior to treatment, on 8 June 2004 at eight months post-treatment sample, and on 27 October 2004 at one year post-treatment. The EWU lab provided data to determine the ratio of cladocerans to copepods. The pretreatment ratio was 1.36:1, and declined to 0.29:1 at eight months post-treatment, and increased again to 1.21:1 at one year post-treatment.

Dusty Lake (Grant Co.) was sampled at the time of treatment on 4 November 2003, and on 16 October 2004 at one year post-treatment. The sample taken six months post-treatment was found to be missing at time of analysis. At the time of treatment, the ratio of cladocerans to copepods was determined by the LLRT to range from 0.20:1 to 0.44:1. This ratio was not significantly different at one year post-treatment, where 3 sample ratios ranged from 0.29:1 to 0.49:1. The density of zooplankton one year post-treatment was significantly lower in all samples. The average length of cladocerans ranged from 0.910 mm to 1.202 mm at the time of treatment, and was in the same range at 0.763 mm to 1.011 mm at one year post-treatment. The average length of copepods ranged from 0.772 mm to 0.940 mm pre-treatment, and increased significantly to a range of 1.539 mm to 1.697 mm at one year post-treatment.

Blue Lake in Okanogan County's Sinlahekin area was sampled at the time of treatment (14 November 2003; mislabeled as 10-14-2003 in LLRT report), and on 24 November 2004 one year post-treatment. The sample taken at six months post-treatment was found to be missing at time of analysis. The ratio of cladocerans to copepods in the pre-treatment sample was determined by the LLRT as 1.17:1; this ratio had declined slightly to 0.92:1 at one year post-treatment. The average length of cladocerans increased from 1.014 mm pre-treatment, to 1.391 mm after one year post-treatment. The average length of copepods declined from 1.104 mm to 0.855 during the same period.

2004-2005

The Hampton Lakes chain (Grant Co.) of 16 lakes and sloughs was treated October 12-22, 2004. Upper Hampton Lake was sampled as the representative of the lake chain. Upper Hampton was treated on 13 October 2004 and pre-treatment samples were taken that day. Samples were taken on 12 May 2005 (reported as 05/12/2003 in the LLRT report) at seven months post-treatment, as the lake was frozen over at the six month point. Logistical problems precluded taking the zooplankton sample at one year post-treatment, and the samples were not taken until 22 April 2006. The LLRT reported the ratio of cladocerans to copepods pre-treatment as ranging from 0.76:1 to 2.28:1. At seven months post-treatment, the ratio had declined to a range between 0.03:1 and 0.09:1. At Upper Hampton Lake eighteen months post-treatment, the ratios had increased to a range between 1.01:1 and 2.66:1 – slightly higher than the pre-treatment levels. The average lengths of cladocerans ranged from 0.216 mm to 0.281 mm pre-treatment. At seven months, the average lengths of cladocerans had significantly increased to a range of 0.945 mm to 1.097 mm. These average lengths remained high at eighteen months post-treatment, ranging from 1.005 mm to 1.247 mm. The average lengths of copepods ranged from 0.654 mm to 0.875 mm pre-treatment, remained the same at between 0.673 mm and 0.740 mm at seven months post-treatment, and increased significantly to between 0.892 mm and 1.006 mm at eighteen months post-treatment.

The WDFW's **North Potholes** Wildlife Management Area in Grant County was sampled prior to the time of treatment on 30 September. Because of ice cover at the six month post-treatment date in March 2005, the sample was not taken until 10 June 2005 at eight months post-treatment, and the one year post-treatment samples were taken on 5 November 2005. The LLRT reported the ratio of cladocerans to copepods as ranging from 0.25:1 to 5.11:1 at the time of the North Potholes treatment. At eight months post-treatment the ratio was within that range, at 0.34:1. The ratios at one year post-treatment ranged from 3.87:1 to 8.54:1, a significant increase. The average lengths of cladocerans at the time of treatment ranged from 0.296 mm to 0.428 mm. Average lengths of cladocerans and copepods were unable to be determined from the samples taken in June 2005. Average lengths of cladocerans at one year post-treatment had increased significantly, ranging between 0.587 mm and 0.965 mm. Average lengths of copepods appeared unchanged from time of treatment (0.789 – 0.912 mm) and one year post-treatment (0.836-0.953 mm)

Fish Lake (Okanogan Co.) was sampled at the time of treatment on 9 October 2004, on 14 April 2005 at six months post-treatment, and on 15 October 2005 at one year post-treatment. The ratio of cladocerans to copepods was 85.00:1 at the time of treatment. At six months post-treatment the ratio had declined to 1.40:1, and increased to

12.96:1 by one year post-treatment. The average length of Fish Lake cladocerans increased from 0.699 mm at time of treatment to 1.165 mm at six months post-treatment, and remained at 1.030 mm at one year post-treatment. There were no measurements available for the few copepods present at the time of treatment. At six months post-treatment, average length of copepods was 0.830 mm, and had increased significantly to 1.416 mm at one year post-treatment.

Silver Nail Lake (Okanogan Co.) samples taken on 20 October 2004 prior to treatment on 21 October, and on 15 April 2005 at six months post-treatment were analyzed. The sample taken one year post-treatment has not yet been analyzed. The LLRT reported the ratio of cladocerans to copepods at 99.67:1 at the time of treatment. At six months post-treatment the ratio had declined to 15.45:1. The average length of cladocerans was 0.668 mm at time of treatment, and remained similar at 0.635 mm at six months post-treatment. No measurements were possible on samples of copepods taken at time of treatment, but were 1.146 mm at six months.

Ellen Lake (Ferry Co.) was sampled on 26 October 2004 at the time of treatment, on 28 April 2005 at six months post-treatment, and on 25 October 2005 at one year post-treatment. The samples taken at the time of treatment were analyzed by the EWU lab, which reported the pre-treatment ratio of cladocerans to copepods as 3.04:1. This ratio declined significantly when the six-month post-treatment samples were reported by the LLRT at a range between 0.10:1 and 1.14:1. The LLRT analyses at one year post-treatment showed an increase to between 1.03:1 and 2.22:1. The average length of cladocerans at six months post-treatment ranged from 0.562 mm to 0.952 mm and remained within that range at the one year period, averaging between 0.613 mm and 0.940 mm. Average length of copepods at six months post treatment ranged between 1.204 mm and 1.303 mm and remained within that range at one year post-treatment, with average lengths ranging from 1.150 mm and 1.292 mm.

Rocky Lake (Stevens Co.) was sampled on 25 October 2004 (misreported as 25 October 2003 in LLRT report), prior to treatment on 26 October. Samples were taken on 27 April 2005 at six months post-treatment, and on 25 October 2005 at one year post-treatment. The LLRT reported the ratio of cladocerans to copepods at 15.00:1 at the time of treatment. At six months post-treatment the ratio had significantly declined to 0.015:1, and again increased to 12.95:1 by one year post-treatment. The average lengths of cladocerans was 1.235 mm at the time of treatment, declined significantly to 0.660 mm at six months, and recovered to 1.205 mm at one year post-treatment. The average lengths of copepods showed a similar response, averaging 1.869 mm at the time of treatment, declining significantly to 0.567 mm at six months, and recovering to 1.607 mm at one year post-treatment.

Rat Lake (Okanogan Co.) was sampled on 9 May 2005 prior to treatment on 10 May 2005, on 15 November 2005 at six months post-treatment, and on 17 May 2006 at one year post-treatment. The pond on the inlet stream immediately above Rat Lake, referred to as "Mouse Pond", was not sampled, as sampling Rat Lake was considered to be representative of the project. The LLRT reported the ratio of cladocerans to copepods at 8.48:1 at the time of treatment. At six months post-treatment the ratio had declined to 0.70:1, and increased slightly to 0.86:1 by one year post-treatment. The average length of cladocerans was 1.498 mm at the time of treatment, declined to 0.968 mm at six months,

and remained at 0.920 mm at one year post-treatment. The average lengths of Rate Lake copepods showed a similar response, averaging 1.182 mm at the time of treatment, declining slightly to 0.981 mm at six months, and recovering to 1.051 mm at one year post-treatment.

2005-2006

Spectacle Lake (Okanogan Co.) was sampled at the time of treatment on 17 October 2005, six months post-treatment, and one year post-treatment. Six month and one year post-treatment samples from Spectacle Lake have not yet been analyzed. The analysis of zooplankton sampling at Spectacle Lake will be published in a subsequent report.

Big Green Lake (Okanogan Co.) was sampled on 11 October 2005, prior to the 12 October treatment, and on 17 April 2006 at six months post-treatment. The sample taken one year post-treatment has not yet been analyzed. The pre-treatment sample revealed a cladoceran to copepod ratio of 0.79:1. This significantly increased to 33.82:1at six months post-treatment, although there were considerably fewer total individuals in the sample. The average length of cladocerans increased slightly to 0.629 mm from 0.500 mm during the first six months. The LLRT was unable to determine average lengths of copepods in the pre-treatment sample, but the six month post-treatment sample showed an average length of 0.839 mm.

Quincy Lake (Grant Co.) was also sampled at the time of treatment on 10 October 2005, on 11 April 2006 at six months post-treatment, and on 26 September 2006 at one year post-treatment. The pre-treatment sample revealed a cladoceran to copepod ratio of between 1.31:1 and 11.56:1. This declined to between 0.35:1 and 3.13:1 at six months post-treatment, then remained between 0.54:1 and 1.64:1 at one year post-treatment. Average length of cladocerans increased significantly from between 0.530 mm and 0.727 mm pre-treatment to 1.846 mm at six months post-treatment. Average lengths remained high, from 0.892 to 1.764 at one year post-treatment. The average lengths of copepods increased slightly from between 0.843 mm and 0.992 mm pre-treatment to between 0.804 mm and 1.183 mm at six months post-treatment, then increased to between 1.238 mm and 1.800 mm at one year post-treatment.

Burke Lake (Grant Co.) was sampled at the time of treatment on 10 October 2005, on 10 April 2006 at six months post-treatment, and on 26 September 2006 at one year post-treatment. One of the samples taken on 10 April 2006 was mislabeled in the LLRT report (Appendix I) as being taken on 15 November 2005. The pre-treatment sample revealed a cladoceran to copepod ratio of between 2.17:1 and 5.05:1. This significantly declined to between 0.007:1 and 0.086:1 at six months post-treatment, then recovered to between 4.05:1 and 4.96:1 at one year post-treatment. There were no measurable cladocerans found in the six month post-treatment sample. Average length of cladocerans increased significantly from between 0.59 mm and 0.728 mm pre-treatment to between 1.510 mm and 2.089 mm at one year post-treatment. The average lengths of copepods declined slightly from between 0.781 mm and 0.939 mm pre-treatment to between 0.601 mm and 0.726 mm at six months post-treatment, then increased significantly to between 0.928 mm and 1.043 mm at one year post-treatment.

Discussion

Changes in the abundance and/or structure of the plankton community by the use of chemicals like rotenone can have marked effects on subsequent fish populations that depend on plankton either directly or indirectly for nutrition. Hoffman and Olive (1961) conducted an experiment to document the effect of rotenone on the zooplankton community in a Colorado reservoir from 1954-1955. They observed a complete kill of protozoans and Entomostracans and a major reduction in the Rotifer population following the treatment. Their finding agreed with previous research (Hooper, 1948; Brown and Ball, 1943; Hamilton, 1941) and more recent findings have demonstrated that rotenone is indeed variably toxic to zooplankton communities (Melaas et al., 2001; Beal and Anderson, 1993; Neves, 1975; Anderson, 1970; Kiser et al, 1963), especially in acidic conditions (Kiser et al. 1963).

Unlike many benthic invertebrates, which may escape the immediate effects of rotenone by burrowing into sediment, zooplankton are exposed to rotenone for the full duration of its activity in the water column. However, populations may recover from resistant life-stages and or eggs (Kiser et al. 1963). A full recovery of the zooplankton community may take longer however. Beal and Anderson (1993) demonstrated that some populations make take up to 8 months to recover following rotenone treatment, while Anderson (1970) noted a 3-year recovery period in two mountain lakes.

Therefore, when rotenone is used in a fisheries management program where future restocking and growth of game fish depends on naturally produced food items are depended upon, consideration must be given for an adequate amount of time for the zooplankton communities to re-establish themselves, before fish are re-introduced into the lake.

Field studies examining the effect of rotenone on aquatic macroinvertebrate communities have provided varied results. Whereas some workers noticed dramatic, long-term effects (Mangum and Madrigal 1999; Binns 1967), others observed rotenone has a negligible effect on most aquatic macroinvertebrates (Demong, 2001; Melaas, 2001). Most researchers would agree, however, that the effects of rotenone are less pronounced and more variable to macroinvertebrates than the effects of the chemical on zooplankton. Like the range of sensitivities demonstrated by various fish species to rotenone, different species of aquatic macroinvertebrates also exhibit a range of tolerances (Mangum and Madrigal, 1999; Chandler and Marking; 1982; Engstrom-Heg et al., 1978) again perhaps based on their oxygen requirements.

The results of monitoring the zooplankton in lakes treated with rotenone under Permit No. WA0041009 reveals a similar variability. The short-term effects appear to be temporary, with most taxa or groups of taxa recovering to pre-treatment levels, or re-establishing populations and relative abundances of cladocerans and copepods that reflect a modified predatory assemblage.

It is expected that rotenone will reduce overall populations of zooplankton immediately subsequent to treatment of the lake, but that zooplankton communities will fully recover in almost all cases (Bradbury 1986). Following an autumn treatment, zooplankton recovery will be slow due to low water temperatures through the winter months. As the water

warms and primary production results in growth of phytoplankton, the remaining zooplankton populations respond positively and proportionally.

The zooplankton populations at the time of treatment were influenced by the predatory effects of populations of fish deemed undesirable for the game fish management plan of the individual lake. It is expected that, subsequent to rotenone treatment and the re-stocking of desirable game fish, the zooplankton populations will re-establish themselves at levels somewhat different to the pre-treatment state. A variety of temporary shifts in zooplankton community structure occur during the post-treatment period, with the most common shift being toward larger-sized cladocerans while fish are absent (Bradbury 1986). When fish are reintroduced, the zooplankton community returns to a structure, level of abundance, and diversity more closely resembling that observed pre-treatment.

Literature Cited

Anderson, R.S. 1970. Effects of rotenone on zooplankton communities and a study of their recovery patterns in two mountain lakes in Alberta. J. Fish Res. Bd. Can. 27: 1335-1356.

Beal, D. L. and R.V. Anderson. 1993. Response of zooplankton to rotenone in a small pond. Bulletin of Environmental Contamination and Toxicology. Vol. 51: 551-556.

Binns, N.A. 1967. Effects of rotenone treatment on the fauna of the Green River, Wyoming. Fisheries Research Bulletin 1. Wyoming Fish and Game Commission, Cheyenne. 114pp.

Bradbury, A. 1986. Rotenone and trout stocking. Washington Department of Game, Fisheries Management Division. Fish. Manage. Rep. 86-2. 181 pp.

Brown, C. J. D., and R. C. Ball. 1943. An experiment in the use of derris root (rotenone) on the fish and fish-food organisms of Third Sister Lake. *Transactions of the American Fisheries Society*. 72: 267-284.

Chandler, J.H. Jr., and L.L. Marking. 1982. Toxicity of rotenone to selected aquatic invertebrates and frog larvae. Progressive Fish Culturist. 44(2): 78-80.

Demong, L. 2001. The use of rotenone to restore native brook trout in the Adirondack Mountains of New York - an overview. pp. 29-35 *in* R.L. Cailteux, L. DeMong, B.J. Finlayson, W. Horton, W. McClay, R.A. Schnick, and C. Thompson, eds. Rotenone in fisheries: are the rewards worth the risks? American Fisheries Society. Trends in Fisheries Science and Management 1, Bethesda, Maryland.

Engstrom-Heg, R., R.T. Colesante and E. Silco. 1978. Rotenone tolerances of stream-bottom insects. *New York Fish and Game Journal.* 25(1): 31-41.

Hamilton, H.L. 1941. The biological action of rotenone on freshwater animals. *Proceedings from Iowa Academy of Sciences.* 48: 467-479.

Hoffman, D.A., and J.R. Olive. 1961. The effects of rotenone and toxaphene upon plankton of two Colorado reservoirs. Journal of Limnology and Oceanography. 6: 219-222.

Hooper, F. F. 1948. The effect of derris root (rotenone) upon plankton and bottom fauna organisms of a small Minnesota lake. *Proceedings from Minnesota Academy of Sciences.* 16: 29-32.

Kiser R.W., J.R. Donaldson, and P.R. Olson. 1963. The effect of rotenone on zooplankton populations in freshwater lakes. *Transactions of the American Fisheries Society.* 92:17–24.

Mangum F.A., and J.L. Madrigal. 1999. Rotenone Effects on Aquatic Macroinvertebrates of the Strawberry River, Utah: A Five-Year Summary. *Journal of Freshwater Ecology.* 14(1): 125-134.

Marking, L.L., and T.D. Bills. 1976. Toxicity of rotenone to fish in standardized laboratory tests. *U.S. Fish and Wildlife Service Investigations in Fish Control.* 72: 1-11.

Melaas, C.L., K.D. Zimmer, M.G. Butler and M.A. Hanson. 2001. Effects of rotenone on aquatic invertebrate communities in prairie wetlands. *Hydrobiologia.* Vol. 459: 177-186.

Neves, R.J. 1975. Zooplankton recolonization of a lake cove treated with rotenone. *Transactions of the American Fisheries Society.* 104(2): 390–393.

Sanders, H.O., and O.B. Cope. 1968. The relative toxicities of several pesticides to naiads of three species of stoneflies. *Journal of Limnology and Oceanography.* 13(1):112-117.

Table 2. Locations and dates for samples of zooplankton sampled under NPDES Permit No. WA0041009 from 2002-03 through 2005-06. Cladoceran to copepod ratios, and average lengths in millimeters.

2002-03 Lakes Treated	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
ALTA LAKE	10/15/2002			
Pre-Treatment	10/01/2002	0.009:1	N/A	0.932
Six Month Post-Treatment	Not Sampled	N/A	N/A	N/A
One Year Post-Treatment	11/14/2003	0.901:1	0.826	1.014
BADGER LAKE	10/22/2002			
Pre-Treatment	10/21/2002	N/A	N/A	N/A
Six Month Post-Treatment	Missing	N/A	N/A	N/A
One Year Post-Treatment	10/01/2003	0.95:1	N/A	N/A
DIBBLE LAKE	10/16/2002			
Pre-Treatment	10/15/2002	N/A	N/A	N/A
Six Month Post-Treatment	Not Sampled	N/A	N/A	N/A
One Year Post-Treatment	Not Sampled	N/A	N/A	N/A
ANCIENT LAKE (SOUTH)	10/17/2002			
Pre-Treatment	10/17/2002	0.47:1 – 1.23:1	0.352 – 0.400	0.785 – 0.871
Six Month Post-Treatment	04/25/2003	0.04:1	N/A	N/A
One Year Post-Treatment	11/07/2003	0.56:1 – 0.72:1	1.061 – 1.173	0.742 – 0.883
NORTH SILVER LAKE	10/24/2002			
Pre-Treatment	10/23/2002	N/A	N/A	N/A
Six Month Post-Treatment	Missing	N/A	N/A	N/A
One Year Post-Treatment	Missing	N/A	N/A	N/A
WILLIAMS LK (Stevens Co)	10/25/2002			
Pre-Treatment	10/25/2002	4.22:1	N/A	N/A
Six Month Post-Treatment	April 2003	0.30:1	N/A	N/A
One Year Post-Treatment	10/25/2003	N/A	N/A	N/A
MARTHA LAKE	03/25/2003			
Pre-Treatment	03/25/2003	0.36:1 - 2.95:1	0.596 – 0.722	0.786 – 0.829
Six Month Post-Treatment	10/24/2003	10.90:1 – 16.30:1	0.981 – 1.204	0.925 – 1.124
One Year Post-Treatment	Missing	N/A	N/A	N/A
DAVIS LAKE	04/07/2003			
Pre-Treatment	Not Sampled	N/A	N/A	N/A
Six Month Post-Treatment	11/14/2003	12.20:1	1.012	1.301
Two Year Post-Treatment	04/19/2005	29.73:1	N/A	N/A
2003-04 Lakes Treated	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
FISHTRAP LAKE	10/06/2003			
Pre-Treatment	10/01/2003	2.46:1	N/A	N/A
Eight Mo Post-Treatment	06/08/2004	7.37:1	N/A	N/A
One Year Post-Treatment	10/27/2004	8.44:1	N/A	N/A
HOG CANYON LAKE	10/07/2003			
Pre-Treatment	10/01/2003	12.63:1	N/A	N/A
Six Month Post-Treatment	04/26/2004	3.09:1	N/A	N/A
Eight Mo Post-Treatment	06/08/2004	4.40:1	N/A	N/A
One Year Post-Treatment	10/27/2004	0.68:1	N/A	N/A

Table 2, continued. Locations and dates for samples of zooplankton sampled under NPDES Permit No. WA0041009 from 2002-03 through 2005-06. Cladoceran to copepod ratios, and average lengths in millimeters.

2003-04 Lakes Treated	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
WILLIAMS LK (Spokane Co)	10/08/2003			
Pre-Treatment	10/01/2003	1.36:1	N/A	N/A
Eight Mo. Post-Treatment	06/08/2004	0.29:1	N/A	N/A
One Year Post-Treatment	10/27/2004	1.21:1	N/A	N/A
DUSTY LAKE	11/04/2003			
Pre-Treatment	11/04/2003	0.20:1 – 0.43:1	0.910 – 1.202	0.772 – 0.940
Six Month Post-Treatment	Missing	N/A	N/A	N/A
One Year Post-Treatment	10/16/2004	0.29:1 – 0.49:1	0.763 – 1.011	1.539 – 1.697
BLUE LAKE (Sinlahekin)	11/14/2003			
Pre-Treatment	11/14/2003	1.17:1	1.014	1.104
Six Month Post-Treatment	Missing	N/A	N/A	N/A
One Year Post-Treatment	11/24/2004	0.92:1	1.391	0.855

2004-05 Lakes Treated	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
Hampton Chain Of Lakes	10/12-15/2004			
Upper Hampton Lake	10/13/2004			
Pre-Treatment	10/13/2004	0.76:1 – 2.28:1	0.265 – 0.281	0.654 – 0.875
Seven Mo Post-Treatment	05/12/2005	0.03:1 – 0.09:1	0.945 – 1.097	0.673 – 0.740
18 Month Post-Treatment	04/22/2006	1.01:1 – 2.66:1	1.005 – 1.247	0.892 – 1.006
NORTH POTHOLES	10/01/2004			
Pre-Treatment	09/30/2004	0.25:1 – 5.11:1	0.296 – 0.428	0.789 – 0.912
Eight Mo Post-Treatment	06/10/2005	0.35:1	N/A	N/A
One Year Post-Treatment	11/05/2005	3.87:1 – 8.54:1	0.587 – 0.965	0.836 – 0.953
FISH LAKE	10/09/2004			
Pre-Treatment	10/09/2004	85.00:1	0.699	N/A
Six Month Post-Treatment	04/15/2005	1.40:1	1.165	0.830
One Year Post-Treatment	10/15/2006	12.96:1	1.030	1.416
SILVER NAIL LAKE	10/21/2004			
Pre-Treatment	10/20/2004	99.67:1	0.668	N/A
Six Month Post-Treatment	04/15/2005	15.45:1	0.635	1.140
One Year Post-Treatment	Not yet analyzed	N/A	N/A	N/A
ELLEN LAKE	10/26/2004			
Pre-Treatment	10/26/2004	3.04:1	N/A	N/A
Six Month Post-Treatment	04/28/2005	0.74:1 – 1.14:1	0.562 – 0.952	1.204 – 1.303
One Year Post-Treatment	10/25/2005	1.03:1 – 2.22:1	0.613 – 0.940	1.150 – 1.292
ROCKY LAKE	10/26/2004			
Pre-Treatment	10/25/2004	15.00:1	1.235	1.869
Six Month Post-Treatment	04/27/2005	0.015:1	0.660	0.567
One Year Post-Treatment	10/25/2005	12.96:1	1.205	1.607
RAT LAKE	05/10/2005			
Pre-Treatment	05/09/2005	8.48:1	1.498	1.182
Six Month Post-Treatment	11/15/2005	0.70:1	0.968	0.981
One Year Post-Treatment	05/17/2006	0.86:1	0.920	1.051

Table 2, continued. Locations and dates for samples of zooplankton sampled under NPDES Permit No. WA0041009 from 2002-03 through 2005-06. Cladoceran to copepod ratios, and average lengths in millimeters.

2005-06 Lakes Treated	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
BIG GREEN LAKE	10/12/2005			
Pre-Treatment	10/11/2005	0.79:1	0.500	0.839
Six Month Post-Treatment	04/17/2006	33.82:1	0.629	N/A
One Year Post-Treatment	Not yet analyzed	N/A	N/A	N/A
SPECTACLE LAKE	10/17/2005	All Samples Not Analyzed	Not Analyzed	Not Analyzed
QUINCY LAKE	10/10/2005			
Pre-Treatment	10/10/2005	1.31:1 – 11.56:1	0.530 – 0.727	0.843 – 0.992
Six Month Post-Treatment	04/11/2006	0.35:1 – 3.13:1	1.846	0.804 – 1.183
One Year Post-Treatment	09/26/2006	0.54:1 – 1.64:1	0.892 – 1.764	1.238 – 1.800
BURKE LAKE	10/10/2005			
Pre-Treatment	11/15/2005	2.17:1 – 5.05:1	0.590 – 0.728	0.781 – 0.939
Six Month Post-Treatment	04/10/2006	0.007:1 – 0.086:1	N/A	0.601 – 0.726
One Year Post-Treatment	09/26/2006	4.05:1 – 4.96:1	1.510 – 2.089	0.928 – 1.043

Table 3. Response of cladocerans and copepods at six months and one year post-treatment.

2002-03	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
ALTA LAKE	10/15/2002			
Pre-Treatment	10/01/2002	--	--	--
Six Month Post-Treatment	Not Sampled	**N/A**	**N/A**	**N/A**
One Year Post-Treatment	11/14/2003	**Significant Increase**	**N/A**	**Unchanged**
BADGER LAKE	10/22/2002			
Pre-Treatment	10/21/2002	--	--	--
Six Month Post-Treatment	Missing	**N/A**	**N/A**	**N/A**
One Year Post-Treatment	10/01/2003	**N/A**	**N/A**	**N/A**
DIBBLE LAKE	10/16/2002			
Pre-Treatment	10/15/2002	--	--	--
Six Month Post-Treatment	Not Sampled	**N/A**	**N/A**	**N/A**
One Year Post-Treatment	Not Sampled	**N/A**	**N/A**	**N/A**
ANCIENT LAKE (SOUTH)	10/17/2002			
Pre-Treatment	10/17/2002	--	--	--
Six Month Post-Treatment	04/25/2003	**Significant Decline**	**N/A**	**N/A**
One Year Post-Treatment	11/07/2003	**Returned to Pre-Treatment Level**	**Significant Increase**	**Unchanged**
NORTH SILVER LAKE	10/24/2002			
Pre-Treatment	10/23/2002	--	--	--
Six Month Post-Treatment	Missing	**N/A**	**N/A**	**N/A**
One Year Post-Treatment	Missing	**N/A**	**N/A**	**N/A**
WILLIAMS LAKE	10/25/2002			
Pre-Treatment	10/25/2002	--	--	--
Six Month Post-Treatment	April 2003	**Declined**	**N/A**	**N/A**
One Year Post-Treatment	10/25/2003	**N/A**	**N/A**	**N/A**
MARTHA LAKE	03/25/2003			
Pre-Treatment	03/25/2003	--	--	--
Six Month Post-Treatment	10/24/2003	**Increased Significantly**	**Increased Significantly**	**Increased Slightly**
One Year Post-Treatment	Missing	**N/A**	**N/A**	**N/A**
DAVIS LAKE	04/07/2003			
Pre-Treatment	Not Sampled	--	--	--
Six Month Post-Treatment	11/14/2003	**N/A**	**N/A**	**N/A**
Two Year Post-Treatment	04/19/2005	**Increase**	**N/A**	**N/A**

Table 3, Continued. Response of cladocerans and copepods at six months and one year post-treatment.

2003-04	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
FISHTRAP LAKE	10/06/2003			
Pre-Treatment	10/01/2003	--	--	--
Six Month Post-Treatment	06/08/2004	**Increase**	**N/A**	**N/A**
One Year Post-Treatment	10/27/2004	**Slight Increase**	**N/A**	**N/A**
HOG CANYON LAKE	10/07/2003			
Pre-Treatment	10/01/2003	--	--	--
Six Month Post-Treatment	04/26/2004	**Significant decline**	**N/A**	**N/A**
Eight Month Post-Treatment	06/08/2004	**Slight increase**	**N/A**	**N/A**
One Year Post-Treatment	10/27/2004	**Significant decline**	**N/A**	**N/A**
WILLIAMS LAKE	10/08/2003			
Pre-Treatment	10/01/2003	--	--	--
Six Month Post-Treatment	06/08/2004	**Significant decline**	**N/A**	**N/A**
One Year Post-Treatment	10/27/2004	**Increase to pre-treatment level**	**N/A**	**N/A**
DUSTY LAKE	11/04/2003			
Pre-Treatment	11/04/2003	--	--	--
Six Month Post-Treatment	Missing	**N/A**	**N/A**	**N/A**
One Year Post-Treatment	10/16/2004	**Unchanged**	**Unchanged**	**Significant Increase**
BLUE LAKE (Sinlahekin)	11/14/2003			
Pre-Treatment	11/14/2003	--	--	--
Six Month Post-Treatment	Missing	**N/A**	**N/A**	**N/A**
One Year Post-Treatment	11/24/2004	**Slight Decline**	**Increase**	**Decline**

2004-05	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
Hampton Chain Of Lakes	10/12-15/2004			
Upper Hampton Lake	10/13/2004			
Pre-Treatment	10/13/2004	--	--	--
Seven Month Post-Treatment	05/12/2003	**Significant decline**	**Significant Increase**	**Unchanged**
18 Months Post-Treatment	04/22/2006	**Increase to pre-treatment level**	**Remained high**	**Significant Increase**
NORTH POTHOLES	10/01/2004			
Pre-Treatment	09/30/2004	--	--	--
Eight Month Post-Treatment	06/10/2005	**Unchanged**	**N/A**	**N/A**
One Year Post-Treatment	11/05/2005	**Significant Increase**	**Significant Increase**	**Unchanged**

Table 3, Continued. Response of cladocerans and copepods at six months and one year post-treatment.

2004-05	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
FISH LAKE	10/09/2004			
Pre-Treatment	10/09/2004	--	--	--
Six Month Post-Treatment	04/15/2005	**Significant decline**	**Significant Increase**	**N/A**
One Year Post-Treatment	10/15/2006	**Increase**	**Remained high**	**Significant Increase**
SILVER NAIL LAKE	10/21/2004			
Pre-Treatment	10/20/2004	--	--	--
Six Month Post-Treatment	04/15/2005	**Significant decline**	**Remained Same**	**N/A**
One Year Post-Treatment	Not yet analyzed	**N/A**	**N/A**	**N/A**
ELLEN LAKE	10/26/2004			
Pre-Treatment	10/26/2004	--	--	--
Six Month Post-Treatment	04/28/2005	**Significant Decline**	**N/A**	**N/A**
One Year Post-Treatment	10/25/2005	**Increase**	**Remained Same**	**Remained Same**
ROCKY LAKE	10/26/2004			
Pre-Treatment	10/25/2004	--	--	--
Six Month Post-Treatment	04/27/2005	**Significant decline**	**Significant decrease**	**Significant decrease**
One Year Post-Treatment	10/25/2005	**Increase to pre-treatment level**	**Increase to pre-treatment level**	**Significant Increase**
RAT LAKE	05/10/2005			
Pre-Treatment	05/09/2005	--	--	--
Six Month Post-Treatment	11/15/2005	**Significant decline**	**Decreased**	**Slight decrease**
One Year Post-Treatment	05/17/2006	**Remained Same**	**Remained Same**	**Remained Same**

2005-06	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
BIG GREEN LAKE	10/12/2005			
Pre-Treatment	10/11/2005	--	--	--
Six Month Post-Treatment	04/17/2006	**Significant increase**	**Slight increase**	**N/A**
One Year Post-Treatment	Not yet analyzed	**N/A**	**N/A**	**N/A**
SPECTACLE LAKE	10/17/2005	**Sample Analysis Not Included This Report**	**All Samples Not Yet Analyzed**	**All Samples Not Yet Analyzed**
QUINCY LAKE	10/10/2005			
Pre-Treatment	10/10/2005	--	--	--
Six Month Post-Treatment	04/11/2006	**Decline**	**Significant Increase**	**Increase**
One Year Post-Treatment	09/26/2006	**Remained same**	**Remained high**	**Slight increase**

Table 3, Continued. Response of cladocerans and copepods at six months and one year post-treatment.

2005-06	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
BURKE LAKE	10/10/2005			
Pre-Treatment	11/15/2005	--	--	--
Six Month Post-Treatment	04/10/2006	**Significant decline**	**N/A**	**Slight decrease**
One Year Post-Treatment	09/26/2006	**Increase to pre-treatment level**	**Significant Increase**	**Significant Increase**

# # #

I certify under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Jon. Anderson
13 June 2008

Appendix I

ZOOPLANKTON MONITORING REPORT

WDFW FISH MANAGEMENT PERMIT
NPDES PERMIT No. WA0041009

For the years 2002-2003 through 2005-2006

Zooplankton Identification and Analysis

Washington Department of Fish and Wildlife

May 22, 2007

Prepared for:

Fish Management Division

By:

Rochelle Shipley

Large Lakes Research Team

Introduction

In 2006, the Fish Management Division of the Washington Department of Fish and Wildlife (WDFW) solicited the WDFW Large Lakes Research Team to conduct analyses on zooplankton samples collected during lake rehabilitations from 2002 to 2007. Samples were collected from 19 lakes with multiple samples from each lake, equating to 88 samples.

Methods and Results for Zooplankton Analyses

Preserved zooplankton samples were identified and enumerated (Washington Department of Ecology 2002). For zooplankton samples with less than 500 individuals, the entire sample was enumerated, whereas, samples with more than 500 individuals of any one species were sub-sampled. Prior to sub-sampling, the sample was reduced into a 100 mL beaker using an open-ended nytex mesh cup and diluted ethanol. Using a Hensen-Stempel pipette, 10 mL were removed from the stirred sample to assure a homogenous distribution of zooplankton throughout. The process of sub-sampling was repeated if the initial sub-sample contained more than 500 individuals. Based on the total number of individuals in the sub-sample, the entire sample was estimated.

Relative abundance and mean length (mm) were determined for cladocerans and copepods for each zooplankton sample and sub-sample. Relative abundance was estimated using a Leica 0.8-3.5 x-dissecting microscope. Lengths for copepods and cladocerans (up to 20 individuals of each type) were measured to the nearest 0.02 mm using a stage micrometer (Table 1). The results were reported as a ratio of total cladocerans: total copepods (Table 2).

Table 1. Average zooplankton length (nearest 0.02 mm) ± 2 SE.

Lake	Date	Cladoceran Average Length	SE	Copepod Average Length	SE
Alta Lake	10/01/2002	--	--	0.932	± 0.112
Alta Lake	11/14/2003	0.826	± 0.083	1.014	± 0.111
Big Green Lake	04/17/2006	0.629	± 0.112	--	--
Big Green Lake	10/11/2005	0.500	± 0.061	0.839	± 0.051
Blue Lake	10/22/2006	1.479	± 0.217	0.968	± 0.105
Blue Lake	10/22/2006	1.416	± 0.165	1.067	± 0.091
Blue Lake	10/22/2006	1.510	± 0.159	0.987	± 0.109
Blue Lake (OK)	11/24/2004	1.391	± 0.195	0.855	± 0.144
Blue Lake (OK)	10/14/2003	1.014	± 0.156	1.104	± 0.227
Burke Lake	09/26/2006	1.510	± 0.200	1.005	± 0.090
Burke Lake	09/26/2006	2.089	± 0.937	0.928	± 0.125
Burke Lake	04/10/2006	--	--	0.726	± 0.131
Burke Lake	04/10/2006	--	--	0.723	± 0.109
Burke Lake	11/15/2005	--	--	0.601	± 0.129
Burke Lake	09/26/2006	1.710	± 0.207	1.043	± 0.101
Burke Lake (1)	--	0.633	± 0.064	0.781	± 0.133
Burke Lake (2)	--	0.728	± 0.062	--	--
Burke Lake (3)	--	0.590	± 0.056	0.939	± 0.109
Davis Lake	11/14/2003	1.012	± 0.208	1.301	± 0.256
Dusty Lake	10/16/2004	0.763	± 0.359	1.629	± 0.149
Dusty Lake	11/04/2003	1.094	± 0.194	0.940	± 0.053
Dusty Lake	10/16/2004	1.011	± 0.231	1.697	± 0.128
Dusty Lake	11/04/2003	1.202	± 0.142	0.772	± 0.094
Dusty Lake	10/16/2004	0.949	± 0.180	1.539	± 0.200
Dusty Lake	11/04/2003	0.910	± 0.432	0.889	± 0.048
Ellen Lake (Mid)	10/25/2005	0.778	± 0.153	1.150	± 0.103
Ellen Lake (Mid)	04/28/2005	0.952	± 0.126	1.285	± 0.146
Ellen Lake (N)	10/25/2005	0.940	± 0.136	1.157	± 0.118
Ellen Lake (N)	04/25/2005	0.735	± 0.203	1.204	± 0.221
Ellen Lake (S)	10/25/2005	0.613	± 0.148	1.292	± 0.082
Ellen Lake (S)	04/28/2005	0.562	± 0.128	1.303	± 0.158
Fish Lake	10/15/2006	1.030	± 0.195	1.416	± 0.269
Fish Lake	04/15/2005	1.165	± 0.195	0.830	± 0.050
Fish Lake	10/09/2004	0.699	± 0.085	--	--
Hampton Lake	04/22/2006	1.005	± 0.056	0.942	± 0.128
Hampton Lake	04/22/2006	1.247	± 0.155	1.006	± 0.164
Hampton Lake	04/22/2006	1.123	± 0.175	0.892	± 0.137
Long Lake	10/01/2006	0.400	± 0.050	0.887	± 0.091
Martha Lake	03/25/2003	0.596	± 0.102	0.786	± 0.111
Martha Lake	03/25/2003	0.722	± 0.145	0.829	± 0.099
Martha Lake	10/24/2003	0.981	± 0.114	1.124	± 0.151
Martha Lake	10/24/2003	1.165	± 0.174	1.093	± 0.175
Martha Lake	10/24/2003	1.204	± 0.167	0.925	± 0.153
N. Potholes (E)	09/30/2004	0.428	± 0.051	0.789	± 0.101
N. Potholes (E)	09/30/2004	0.296	± 0.058	0.912	± 0.045
Park Lake	11/16/2006	1.641	± 0.264	0.869	± 0.134
Park Lake	11/16/2006	1.126	± 0.166	0.769	± 0.165
Park Lake	11/16/2006	1.226	± 0.118	0.652	± 0.153
Pearrygin	10/08/2006	0.619	± 0.133	1.321	± 0.185
Potholes	09/28/2006	--	--	0.779	± 0.110
Potholes	09/28/2006	--	--	0.556	± 0.082

Lake	Date	Cladoceran Average Length	SE	Copepod Average Length	SE
Potholes	09/28/2006	--	--	0.487	± 0.067
Potholes	06/10/2005	--	--	--	--
Potholes	11/05/2005	0.587	± 0.086	0.886	± 0.071
Potholes	11/15/2005	0.965	± 0.750	0.836	± 0.131
Potholes	11/15/2005	0.964	± 0.156	0.953	± 0.104
Quincy Lake	09/26/2006	1.735	± 0.237	1.800	± 0.065
Quincy Lake	09/26/2006	1.764	± 0.210	1.769	± 0.095
Quincy Lake	04/11/2006	--	--	1.183	± 0.181
Quincy Lake	04/11/2006	--	--	0.804	± 0.343
Quincy Lake	04/11/2006	1.846	± 0.243	1.091	± 0.216
Quincy Lake	10/10/2005	0.530	± 0.040	0.992	± 0.129
Quincy Lake	10/10/2005	0.727	± 0.101	0.931	± 0.213
Quincy Lake	10/10/2005	0.628	± 0.079	0.843	± 0.121
Quincy Lake	09/26/2006	0.892	± 0.166	1.238	± 0.209
Rat Lake	05/17/2006	0.920	± 0.125	1.051	± 0.271
Rat Lake	11/15/2005	0.968	± 0.162	0.981	± 0.075
Rat Lake	05/09/2005	1.498	± 0.224	1.182	± 0.217
Rocky Lake (N)	04/27/2005	0.660	--	0.567	± 0.054
Rocky Lake (N)	10/25/2005	1.205	± 0.116	1.607	± 0.184
Rocky Lake (S)	10/25/2003	1.235	± 0.106	1.869	± 0.059
S. Ancient	10/11/2002	0.352	± 0.020	0.871	± 0.087
S. Ancient	10/17/2002	0.400	± 0.027	0.785	± 0.114
S. Ancient	11/07/2003	1.061	± 0.131	0.883	± 0.072
S. Ancient	11/07/2003	1.173	± 0.153	0.742	± 0.088
Silvernail Lake	04/15/2005	0.635	± 0.066	1.140	± 0.360
Silvernail Lake	10/20/2004	0.668	± 0.033	--	--
Spectacle Lake	10/17/2005	1.419	± 0.199	1.347	± 0.159
Upper Hampton	05/12/2005	1.062	± 0.144	0.716	± 0.081
Upper Hampton	10/13/2004	0.266	± 0.017	0.875	± 0.170
Upper Hampton	10/13/2004	0.265	± 0.017	0.654	± 0.115
Upper Hampton	05/12/2003	1.097	± 0.281	0.740	± 0.038
Upper Hampton	12/13/2004	0.281	± 0.013	0.862	± 0.141
Upper Hampton	05/12/2003	0.945	± 0.494	0.673	± 0.084
West Lake	04/06/2007	1.380	± 0.297	1.661	± 0.608

Table 2. Zooplankton total enumeration and sub-sample enumeration.

		Total Count Ratio		Sub-sample Ratio	
Lake	**Date**	**Cladocerans**	**Copepods**	**Cladocerans**	**Copepods**
Alta Lake	10/01/2002	3,000	336,000	1.00	112.00
Alta Lake	11/14/2003	37,200	41,300	1.00	1.11
Big Green Lake	04/17/2006	372	11	33.82	1.00
Big Green Lake	10/11/2005	7,600	9,600	1.00	1.26
Blue Lake	10/22/2006	10,900	7,100	1.54	1.00
Blue Lake	10/22/2006	10,270	17,990	1.00	1.75
Blue Lake	10/22/2006	5,500	3,100	1.77	1.00
Blue Lake (OK)	11/24/2004	1,490	1,630	1.00	1.09
Blue Lake (OK)	10/14/2003	24,700	21,200	1.17	1.00
Burke Lake	09/26/2006	12,300	3,040	4.05	1.00
Burke Lake	09/26/2006	15,440	3,110	4.96	1.00
Burke Lake	04/10/2006	60	8,640	1.00	144.00
Burke Lake	04/10/2006	50	5,920	1.00	118.40
Burke Lake	11/15/2005	90	1,050	3.00	35.00
Burke Lake	09/26/2006	14,570	3,260	4.47	1.00
Burke Lake (1)	--	12,280	5,650	2.17	1.00
Burke Lake (2)	--	50,500	15,700	3.22	1.00
Burke Lake (3)	--	30,300	6,000	5.05	1.00
Davis Lake	11/14/2003	24,400	2,000	12.20	1.00
Dusty Lake	10/16/2004	160	550	1.00	3.44
Dusty Lake	11/04/2003	4,600	23,300	1.00	5.07
Dusty Lake	10/16/2004	150	400	1.00	2.67
Dusty Lake	11/04/2003	8,200	34,500	1.00	4.21
Dusty Lake	10/16/2004	290	590	1.00	2.03
Dusty Lake	11/04/2003	13,000	29,800	1.00	2.29
Ellen Lake (Mid)	10/25/2005	1,640	740	2.22	1.00
Ellen Lake (Mid)	04/28/2005	25	34	1.00	1.36
Ellen Lake (N)	10/25/2005	1,610	1,570	1.03	1.00
Ellen Lake (N)	04/25/2005	16	14	1.14	1.00
Ellen Lake (S)	10/25/2005	1,280	750	1.71	1.00
Ellen Lake (S)	04/28/2005	17	178	1.00	10.47
Fish Lake	10/15/2006	3,630	280	12.96	1.00
Fish Lake	04/15/2005	800	570	1.40	1.00
Fish Lake	10/09/2004	85,000	--	85.00	--
Hampton Lake	04/22/2006	3,750	3,100	1.21	1.00
Hampton Lake	04/22/2006	2,530	950	2.66	1.00
Hampton Lake	04/22/2006	2,950	2,910	1.01	1.00
Long Lake	10/01/2006	53,600	6,300	8.51	1.00
Martha Lake	03/25/2003	1,990	5,480	1.00	2.75
Martha Lake	03/25/2003	2,900	1,600	1.81	1.00
Martha Lake	10/24/2003	13,400	1,200	11.17	1.00
Martha Lake	10/24/2003	10,900	1,000	10.90	1.00
Martha Lake	10/24/2003	3,750	230	16.30	1.00
N. Potholes (E)	09/30/2004	68,000	13,300	5.11	1.00
N. Potholes (E)	09/30/2004	1,300	5,200	1.00	4.00
Park Lake	11/16/2006	9,290	3,340	2.78	1.00
Park Lake	11/16/2006	5,780	3,200	1.81	1.00
Park Lake	11/16/2006	9,840	4,020	2.45	1.00
Pearrygin	10/08/2006	1,800	290	6.21	1.00
Potholes	09/28/2006	970	1,080	1.00	1.11
Potholes	09/28/2006	230	550	1.00	2.39

		Total Ratio		Sub-sample Ratio	
Lake	Date	Cladocerans	Copepods	Cladocerans	Copepods
Potholes	09/28/2006	80	220	1.00	2.75
Potholes	06/10/2005	410	1,190	1.00	2.90
Potholes	11/05/2005	7,360	1,900	3.87	1.00
Potholes	11/15/2005	4,870	570	8.54	1.00
Potholes	11/15/2005	2,490	530	4.70	1.00
Quincy Lake	09/26/2006	2,490	2,310	1.08	1.00
Quincy Lake	09/26/2006	2,250	1,370	1.64	1.00
Quincy Lake	04/11/2006	80	230	1.00	2.88
Quincy Lake	04/11/2006	500	160	3.13	1.00
Quincy Lake	10/10/2005	33,900	4,300	7.88	1.00
Quincy Lake	10/10/2005	10,400	900	11.56	1.00
Quincy Lake	10/10/2005	3,370	2,580	1.31	1.00
Quincy Lake	09/26/2006	430	800	1.00	1.86
Rat Lake	05/17/2006	2,640	3,060	1.00	1.16
Rat Lake	11/15/2005	5,680	8,060	1.00	1.42
Rat Lake	05/09/2005	17,800	2,100	8.48	1.00
Rocky Lake (N)	04/27/2005	10	670	1.00	67.00
Rocky Lake (N)	10/25/2005	5,440	420	12.95	1.00
Rocky Lake (S)	10/25/2003	5,850	390	15.00	1.00
S. Ancient	10/11/2002	18,100	30,100	1.00	1.66
S. Ancient	10/17/2002	10,700	8,700	1.23	1.00
S. Ancient	11/07/2003	8,000	11,100	1.00	1.39
S. Ancient	11/07/2003	6,800	12,100	1.00	1.78
Silvernail Lake	04/15/2005	17,000	1,100	15.45	1.00
Silvernail Lake	10/20/2004	59,800	600	99.67	1.00
Spectacle Lake	10/17/2005	5,420	5,670	1.00	1.05
Upper Hampton	05/12/2005	280	10,040	1.00	35.86
Upper Hampton	10/13/2004	2,780	2,990	1.00	1.08
Upper Hampton	10/13/2004	9,100	4,000	2.28	1.00
Upper Hampton	05/12/2003	1,200	13,000	1.00	10.83
Upper Hampton	12/13/2004	3,600	4,700	1.00	1.31
Upper Hampton	05/12/2003	400	8,500	1.00	21.25
West Lake	04/06/2007	3,470	1,130	3.07	1.00

Recommendations

Field Sampling:

Depth should be recorded to calculate the volume of water sampled. Zooplankton density can then be computed from the known volume in the sample and expanded to number/liter, which is useful when comparing data among water bodies. To reduce the error of overestimating zooplankton abundance, each sample should be taken from an anchored site, from the bottom of the lake straight up to the lake surface, rather than at an angle. If a sample contains benthic debris, the sample should be emptied and taken again. In addition, each sample should contain a label tag written in pencil on waterproof paper

(e.g. "Rite in the Rain"®) for site identification. Some of the sample bottles were labeled in permanent ink, which dissolves in ethanol. Consequently, some of the sample bottles lacked pertinent information regarding area of collection and depth. The following information should be recorded on a label:

- Lake Name
- Location of Sample (description or coordinates)
- Date
- Time
- Depth
- Water Temperature

Preservation:

We recommend that the following preservation techniques, similar to those developed by Black and Dodson (2003), be used when collecting zooplankton samples. Immediately following a tow, each sample should be flushed into an open-ended nytex mesh cup designed to capture all zooplankton within the sample while allowing the water to pass through. Once the majority of water has drained from the sample, the nytex cup should be placed in a tray of 95% ethanol for approximately 10 seconds in order to fix the zooplankton. Once the sample is fixed it should be irrigated from the cup with 70% ethanol into a Whirl-Pak® or 125 mL plastic bottle. Samples should be stored in 70% ethanol until lab analysis. To prevent samples from drying, an adequate volume of ethanol should be used to fill the storage vessel. Other types of alcohol such as isopropyl should not be used as they can destroy cladoceran carapaces. During our zooplankton analysis, some cladocerans could not be measured because of carapace deterioration.

Analysis:

The zooplankton sampling protocol (Washington Department of Ecology 2002) requires a cladoceran/copepod ratio for each sample. Although this is the prescribed methodology, we feel an additional descriptive approach may be warranted. The identification of zooplankton to family would provide more information and be useful to temporally and spatially compare samples within and among systems. Furthermore, the

descriptive approach may be useful to detect invasive species such as the zebra mussel (*Dreissena polymorpha*) larvae or veliger, which range in size from 97-228 μm depending on the ontogenetic stage (USACE 2007). However, it should be noted that the sampling efforts associated with the rehabilitation requirements could only supplement, not replace the existing efforts dedicated to detecting invasive species such as zebra mussels.

Cost:

Some of the samples required an extended amount of time due to the presence of benthic debris and/or damaged zooplankton due to inadequate preservation. Based on the amount of time expended to analyze the 88 samples that had been collected over a 6-year period, we estimated a cost of approximately $90.00 per sample. This cost included enumeration, identification, and measurements. This work cost $7,300; however, only $5,500 was provided by the Fish Management Division.

Conclusions:

We recommend that all future samples be analyzed shortly after they are collected to reduce the likelihood of damage to zooplankton carapaces. The methods that we recommended will reduce the volume of alcohol required while maintaining the integrity of zooplankton structures used for analysis. We have constructed all of the necessary equipment needed to follow our methodologies and will gladly supply WDFW staff with these material when needed. Thank you for using the Large Lakes Research Team to perform your mandated tasks and we look forward to becoming more involved in future Lake Rehabilitation Program efforts.

References:

Black, A. R. and S. I. Dodson. 2003. Ethanol: a better preservation technique for *Daphnia*. Limnology and Oceanography: Methods 1:45-50.

United States Army Corp. of Engineers. 2007. http://el.erdc.usace.army.mil/zebra/zmis/zmishelp4/dreissena_polymorpha_zebra_mussel_larva.htm

Washington Department of Ecology. 2002. Fishery Resource Management. National Pollutant Discharge Elimination System, Water Discharge Individual Permit No. WA0041009. Pages 28-29.

APPENDIX II

RESULTS OF ZOOPLANKTON ANALYSES

COMPLETED BY EASTERN WASHINGTON UNIVERSITY

Williams Lake (Stevens County)

Williams Lake (Spokane County)

South Ancient Lake

Martha, Ellen, and Davis Lakes

Hog Canyon Lake

Fishtrap Lake

Badger Lake

Williams Lake (Stevens County)

Date 25 October 2002	Site #1 Density #/L	Site #2 Density #/L	Site #3 Density #/L	Average	SE	
Daphnia pulex	0.153224	0.369313	0.255877	0.259471	0.062405	Cladoceran
Daphnia rosea	1.392943	3.204684	2.204483	2.26737	0.523949	Cladoceran
Ceriodaphnia	0.090541	0.345486	0.413341	0.283123	0.098263	Cladoceran
Bosmina longirostris	0.006965	0	0	0.002322	0.002322	Cladoceran
Mesocyclops	0.111435	0.095307	0.039366	0.082036	0.021837	Copepod
Diaptomus	0.793977	0.309746	0.649535	0.584419	0.143527	Copepod
Chydorus	0.006965	0	0	0.002322	0.002322	Cladoceran
				2.814607	Cladoceran	
				0.666455	Copepod	
				4.22325	Cladoceran:Copepod	

Date April 2003

	Site #1 Density #/L	Site #2 Density #/L	Site #3 Density #/L	Average	SE	
Ceriodaphnia	0	0.023578	0.034788	0.019455	0.010252	Cladoceran
Daphnia pulex	0.61304	0.165049	0.104364	0.294151	0.160404	Cladoceran
Bosmina longirostris	0.377255	0.023578	0.006958	0.13593	0.120758	Cladoceran
Mesocyclops	0.447991	0	0.034788	0.160926	0.143883	Copepod
Diaptomus	4.456328	2.051326	0.43137	2.313008	1.169249	Copepod
Chydorus	0.636618	0.141471	0.0626218	0.280237	0.179638	Cladoceran
Alona	0.023578	0	0	0.007859	0.007859	Cladoceran
Simocephalus	0	0	0.006958	0.002319	0.002319	Cladoceran
				0.739952	Cladoceran	
				2.473934	Copepod	
				0.299099	Cladoceran:Copepod	

Williams Lake (Spokane County)

10/01/2003	Site #1	Site #2	Site #3			
Taxa	Density #/L	Density #/L	Density #/L	Average	SE	
Ceriodaphnia	0.503007	0	0	0.167669	0.167669	Cladoceran
Daphnia pulex	0	5.588094	0	1.862698	1.862698	Cladoceran
Daphnia rosea	12.82668	0	20.19767	11.00812	5.901041	Cladoceran
D. galeata	19.61727	3.183091	22.63532	15.14523	6.044189	Cladoceran
Bosmina longirostris	73.18752	13.36898	20.5459	35.7008	18.85752	Cladoceran
Diacyclops	17.35374	15.56178	49.7977	27.57107	11.12535	Copepod
Mesocyclops	11.82067	1.909855	44.9224	19.55098	13.00433	Copepod
Chydorus	0	0	0.348236	0.116079	0.116079	Cladoceran
				64.00059	Cladoceran	
				47.12205	Copepod	
				1.358188	Cladoceran:Copepod	
06/08/2004	Site #1	Site #2	Site #3			
	Density #/L	Density #/L	Density #/L	Average	SE	
Ceriodaphnia	1.168274	1.891907	0.452706	1.170962	0.415464	Cladoceran
Daphnia pulex	8.469989	10.27035	1.622198	6.787512	2.634431	Cladoceran
Daphnia galeata	4.234995	5.945994	2.753964	4.311651	0.922256	Cladoceran
Bosmina longirostris	0.876206	1.08109	0.33953	0.765609	0.221097	Cladoceran
Diaphanosoma	1.438103	0	0	0.479368	0.479368	Cladoceran
Diacyclops	46.00081	68.6492	13.20393	42.61798	16.09479	Copepod
Mesocyclops	2.04448	0	0.603608	0.882696	0.606463	Copepod
Diaptomus	4.673098	3.243269	2.188081	3.368149	0.720075	Copepod
Chydorus	0	0	0.113177	0.037726	0.037726	Cladoceran
Alona	0	0	0.037726	0.012575	0.012575	Cladoceran
				13.5654	Cladoceran	
				46.86883	Copepod	
				0.289433	Cladoceran:Copepod	
10/27/2004	Site #1	Site #2	Site #3			
	Density #/L	Density #/L	Density #/L	Average	SE	
Daphnia pulex	2.274259	11.94848	7.102806	7.108515	2.792709	Cladoceran
Bosmina longirostris	0	0.296857	0.312211	0.203023	0.101608	Cladoceran
Diaphanosoma	0.042911	0	0	0.014304	0.014304	Cladoceran
Diacyclops	3.153926	6.456631	6.556437	5.388998	1.117907	Copepod
Mesocyclops	0.171642	0	1.404951	0.525531	0.442493	Copepod
Diaptomus	0	0.148428	0.312211	0.153546	0.090164	Copepod
Chaoborus	0.021455	0	0	0.007152	0.007152	Insect
				7.325841	Cladoceran	
				6.068075	Copepod	
				1.207276	Cladoceran:Copepod	

South Ancient Lake

10/17/2002 Taxa	Site 1 Density #/L	Site 2 Density #/L	Site 3 Density #/L	Average	SE	
Daphnia pulex	1.034757	0	0	0.344919	0.344919	Cladoceran
Ceriodaphnia	4.397719	2.716238	2.304687	3.139548	0.640206	Cladoceran
Bosmina longirostris	14.22791	7.016948	8.724886	9.989915	2.175601	Cladoceran
Diaphanosoma	4.139029	0.905413	0.823102	1.955848	1.091849	Cladoceran
Diacyclops	38.02733	22.18261	17.77901	25.99632	6.148357	Copepod
Diaptomus	8.019369	8.827774	2.963169	6.603437	1.835034	Copepod
Chaoborus sp.	0	0	0.16462	0.054873	0.054873	Insect
				15.43023	Cladoceran	
				32.59975	Copepod	
				0.473324	Cladoceran:Copepod	

04/25/2003	Site #1 Density #/L	Site #2 Density #/L	Site #3 Density #/L	Average	SE	
Ceriodaphnia	2.069515	0.905413	2.130383	1.70177	0.398566	Cladoceran
Bosmina longirostris	4.4843948	1.509021	2.982536	2.991984	0.858929	Cladoceran
Diaphanosoma	1.379676	2.414434	0.852153	1.548754	0.458847	Cladoceran
Diacyclops	122.4463	149.9967	193.4388	155.2939	20.66421	Copepod
Diaptomus	3.449191	3.923456	5.112919	4.161855	0.494848	Copepod
				6.242509	Cladoceran	
				159.4558	Copepod	
				0.039149	Cladoceran:Copepod	

Martha Lake

03/25/2003

	Site #1 Density #/L	Site #2 Density #/L	Site #3 Density #/L	Average	SE	
Daphnia rosea	239.0289	135.8119	11.77036	128.8704	65.69564	Cladoceran
D. galeata	79.67631	74.24384	54.77747	69.56587	7.558672	Cladoceran
Bosmina longirostris	34.40568	31.68944	17.65555	27.91689	5.190241	Cladoceran
Diacyclops	72.43301	52.52393	97.78457	74.24717	13.09707	Copepod
Diaptomus	7.243301	2.716238	0	3.319846	2.112629	Copepod
Chydorus	1.1810825	2.716238	3.621651	2.506324	0.712306	Cladoceran
				228.8595	Cladoceran	
				77.56702	Copepod	
				2.950474	Cladoceran:Copepod	

Ellen Lake

Zoop Taxa densities

10/26/2004

	Density #/L					
Taxa	**Site 1**	**Site 2**	**Site 3**	**Average**	**SE**	
Daphnia pulex	11.05648	5.281574	12.37397	9.570675	2.178014	Cladoceran
Bosmina longirostris	1.044707	0.431149	0.226353	0.567403	0.245866	Cladoceran
Mesocyclops	0.78353	0.323362	0.452706	0.519866	0.137018	Copepod
Diacyclops	0	0.215574	0.754511	0.323362	0.224377	Copepod
Diaptomus	7.138831	0.215574	0.150902	2.501769	2.318606	Copepod
Scapholebris	0.087059	0	0	0.02902	0.02902	Cladoceran
				10.1671	Cladoceran	
				3.344997	Copepod	
				3.039494	Cladoceran:Copepod	

Davis lake **All taxa densities are represented as % abundance as no tow lengths were recorded on the sample bottles.**

04/19/2005	**Site 1**	**Site 2**	**Site 3**	**Average**	**SE**	
Daphnia pulex	85.37	93.53	93.617	90.83912	2.736737	Cladoceran
Bosmina longirostris	0.542	0	0	0.180668	0.180668	Cladoceran
Chydorus	7.317	1.94	0.5803	3.279	2.056819	Cladoceran
Ceriodaphnia	1.897	2.155	3.2882	2.446798	0.427251	Cladoceran
Diaptomus	3.523	1.724	2.1277	2.458278	0.544974	Copepod
Diacyclops	1.355	0.647	0.3868	0.796137	0.28932	Copepod

Hog Lake (Hog Canyon)

10/01/2003 Density #/L Zoop Taxa	Site #1	Site 2	Average	SE	
Ceriodaphnia	0.532596	6.671462	3.602029	3.06943	Cladoceran
Daphnia pulex	0.532596	0.953066	0.742831	0.21024	Cladoceran
Daphnia retrocurva	0.535296	0	0.267648	0.26765	Cladoceran
Daphnia thorata	1.065191	0	0.5325955	0.53260	Cladoceran
Bosmina longirostris	385.5993	634.0712	509.83525	124.23595	Cladoceran
Diacyclops	13.31489	36.21651	24.7657	11.45081	Copepod
Diaptomus	4.793361	2.859198	3.8262795	0.96708	Copepod
Chaoborus sp.	0	4.76533	2.382665	2.38267	Insect
Chydorus	13.31489	11.43679	12.37584	0.93905	Copepod
Asplancna	460.1627	538.4823	499.3225	39.15980	Rotifer
Camptocercus	0	0.953066	0.476533	0.47653	Cladoceran
Alona	0	3.812264	1.906132	1.90613	Cladoceran
			517.3630185		Cladoceran
			40.9678195		Copepod
			12.62852221		Cladoceran

04/26/2004 Site #2 Density #/L			06/08/2004 Site #3 Density #/L		
Ceriodaphnia	9.328494	Cladoceran	Ceriodaphnia	19.91908	Cladoceran
Daphnia pulex	3.703961	Cladoceran	Daphnia pulex	13.12848	Cladoceran
Bosmina longirostris	1.646205	Cladoceran	Bosmina longirostris	3.16894	Cladoceran
Diacyclops	5.48735	Copepod	Diaphanasoma	0.45271	Cladoceran
Diaptomus	0.960286	Copepod	Cyclopoid adult sm.	6.33789	Copepod
Chaoborus sp.	5.48735	Insect	Calanoid sp.	2.71624	Copepod
Chydorus	3.841145	Cladoceran	Chaoborus sp.	2.26353	Insect
Asplancna	11.38625	Rotifer	Chydorus	2.26353	Cladoceran
Alona	1.371837	Cladoceran	Asplancna	45.72334	Rotifer
			Alona	0.90541	Cladoceran
	19.891642	Cladoceran		39.83816	Cladoceran
	6.447636	Copepod		9.05413	Copepod
	3.085106231	Cladoceran:Copepod		4.40000	

10/27/2004 Taxa	Site #1 Density #/L	Site #2 Density #/L	Average	SE	
Ceriodaphnia	6.359446	5.658829	6.0091	0.35031	Cladoceran
Daphnia pulex	0.970085	1.131766	1.0509255	0.08084	Cladoceran
Bosmina longirostris	1.832383	1.616808	1.7245955	0.10779	Cladoceran
Diacyclops	1.724596	1.616808	1.670702	0.05389	Copepod
Diaptomus	10.02421	11.47934	10.751775	0.72756	Copepod
Chaoborus sp.	0	0.161681	0.0808405	0.08084	Insect
Chydorus	0.215574	0	0.107787	0.10779	Cladoceran
Asplancna	3.018042	9.539169	6.2786055	3.26056	Rotifer
Epischura	0.431149	0.808404	0.6197765	0.18863	Copepod
			8.8924455		Cladoceran
			13.0422535		Copepod
			0.681818177		Cladoceran:Copepod

Fishtrap Lake
Sample date
10/01/2003

Density #/L

Zoop Taxa	Site 1	Site 2	Site 3	Average	SE	
Daphnia galeata	6.584819	2.263532	4.416647	4.421666	1.247451	Cladoceran
Daphnia rosea	3.29241	0	0.883329	1.391913	0.983867	Cladoceran
Ceriodaphnia sp.	153.6458	443.6522	192.5658	263.2879	90.8793	Cladoceran
Bosmina longirostris	17.55952	11.31766	0.883329	9.92017	4.864448	Cladoceran
Diacyclops	38.41145	56.58829	32.68319	42.56098	7.205955	Copepod
Mesocyclops	29.63169	126.7578	22.08324	59.49091	33.70396	Copepod
Diaptomus	8.779759	11.31766	14.13327	11.41023	1.546118	Copepod
				279.0217	Cladoceran	
				113.4621	Copepod	
				2.459162	Cladoceran:Copepod	

Fishtrap Lake
Sample date
06/08/2004

Density #/L

Zoop Taxa	Site 1	Site 2	Site 3	Average	SE	
Daphnia pulex	28.86003	10.20647	31.91209	23.65953	6.783986	Cladoceran
Ceriodaphnia sp.	14.71296	6.420199	24.78753	15.3069	5.310502	Cladoceran
Diacyclops	3.96118	4.773994	6.085561	4.940245	0.618864	Copepod
Diaptomus	0.377255	0.493861	0.296857	0.389324	0.057189	Copepod
Chaoborus sp.	0.188628	0.16462	0.296857	0.216702	0.040672	Insect
Chydorus	0	0.658482	0.148428	0.26897	0.199414	Cladoceran
Alona	0.188628	0	0	0.062876	0.062876	Cladoceran
				39.29827	Cladoceran	
				5.329569	Copepod	
				7.37363	Cladoceran:Copepod	

Fishtrap Lake
10/27/2004

Density #/L

Zoop taxa	Site 1	Site 2	Site 3	Average	SE	
Ceriodaphnia sp.	8.521531	8.730765	13.45185	10.23472	1.609701	Cladoceran
Daphnia pulex	43.67285	53.67804	36.73389	44.69493	4.917978	Cladoceran
Bosmina longirostris	3.195574	6.143872	10.86495	6.734799	2.233587	Cladoceran
Diacyclops	3.905702	8.084042	9.830195	7.273313	1.757637	Copepod
Diaptomus	0.355064	0.323362	0.517379	0.398602	0.06009	Copepod
Chydorus	0.710128	4.850425	3.362961	2.974505	1.21088	Cladoceran
Diaphanasoma	0	0	0.517379	0.17246	0.17246	Cladoceran
				64.81141	Cladoceran	
				7.671915	Copepod	
				8.447879	Cladoceran:Copepod	

Badger Lake						
Zoop densities						
Inds./liter						
10/01/2003						
Taxa	**Rep1**	**Rep2**	**Rep3**	**Average**	**SE**	
Ceriodaphnia	0.279448	0.226353	0.646723	0.384175	0.132166	Cladoceran
Daphnia pulex	5.365408	2.813247	6.790595	4.98975	1.163424	Cladoceran
Daphnia rosea	12.85462	10.44458	10.9943	11.43117	0.729203	Cladoceran
Bosmina longirostris	1.061904	1.875498	1.161808	1.366403	0.256176	Cladoceran
Diaphanasoma	0.391228	0.258689	0.242521	0.297479	0.047106	Cladoceran
Diacyclops	15.42555	12.1584	24.57549	17.38648	3.716179	Copepod
Diaptomus	3.521049	1.325783	1.697649	2.181494	0.678326	Copepod
Chydorus sphaeracus	0	0	0.08084	0.026947	0.026947	Cladoceran

18.49592 Cladoceran
19.56797 Copepod
0.945214 Cladoceran:Copepod